

**BELLCOMM, INC.**

1100 Seventeenth Street, N.W. Washington, D. C. 20036

**SUBJECT:** LM Supercritical Helium (SHe)  
System - Status of Lunar Mission  
Requirements/Capabilities and  
Proposed Upgrading - Case 320

**DATE:** August 28, 1968

**FROM:** D. M. Duty

ABSTRACT

A summation is given of the results of an MSC review of the proposed upgrading of the SHe system and reduction in the heat leak specification for the storage tank.

The tank cannot be upgraded due to structural limitations. The heat leak specification cannot be reduced until adequate flight data is acquired and analyzed to confirm the tank flight thermal environment.

The present system standby lifetime capability is 131.33 hours compared to a mission requirement of 131.0 hours.

(NASA-CR-73548) LM SUPERCRITICAL HELIUM  
/SHE/ SYSTEM STATUS OF LUNAR MISSION  
REQUIREMENTS/ CAPABILITIES AND PROPOSED  
UPGRADING (Bellcomm, Inc.) 7 p

N79-72336

Unclas  
11299

FF No. 602/A	(PAGES)	7400	00/18
	(NASA CR OR TMX OR AD NUMBER)	CR 73548	
	(CATEGORY)		
	[REDACTED]		

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MEMORANDUM FOR FILEINTRODUCTION

The LM supercritical helium (SHe) system continues to be a constraining factor in lunar mission planning because of its limited standby life capability. The standby life is the maximum time available from "topoff" of the SHe system during pad operations until the maximum allowable operating pressure of the tank is reached. It is a direct function of the rate of pressure rise within the tank from heat leak and the maximum tank pressure, which if exceeded, will result in the operation of the tank pressure relief system, either after descent engine firing or at some later time from continued heat leak. Either case results in the loss of descent engine operational capability. Requirements for pad servicing operations, countdown strategy (built-in holds) and the mission time line presently approach or exceed the design limit of the system standby lifetime.

This memorandum summarizes the results of an MSC review of the proposed recommendation for uprating the SHe system and presents the present status of mission requirements versus system capabilities.

SHe SYSTEM UPRATING

Reference 1 was a summary of SHe system capabilities and lunar mission requirements and included a proposal for uprating the present system to provide additional standby time. At that time, the system standby lifetime was projected to be 160 hours. This number was the result of using a rate of pressure rise within the SHe tank of 9 psia/hr instead of the specification number of 10 psia/hr. All production tanks, accepted to date, have exhibited rates of pressure rise due to heat leak below this number. LM-1 pad tests indicated a pressure rise well under 9.0 psia/hr for that system/environment. Also, a less conservative maximum tank pressure before system activation at Descent Orbit Injection (DOI) was used.

The proposal for uprating the SHe system standby lifetime to provide an additional 34 hours involved reproofing the tank to a higher pressure level and redesign of the pressure relief system (burst discs). The uprated system required reducing the safety factor from 2.0 to 1.5 during the terminal portion of the standby period.

MSC has reviewed the proposed uprating of the system and the heat leak/rate of pressure rise specification with the following results (reference 2):

1. Heat Leak/Rate of Pressure Rise

The 10 psia/hr heat leak specification cannot presently be reduced to 9.0 psia/hr or less due to the lack of adequate flight data to establish the relationship between the rate of pressure rise and actual flight thermal environment. It is also stated that there is likely to be some degradation (amount unpredictable) of the vacuum insulation prior to the scheduled use of the present tanks. Both GAEC and MSC propulsion feel that it is unwise to lower the 10 psia/hr specification until adequate flight data is acquired.

2. Maximum SHe Tank Pressure

The maximum allowable tank pressure before system activation is undefined at this time. It cannot be specified until the DPS duty cycle (first burn profile) is defined. The current estimate is 1400 psia. Previous calculations of standby lifetime used 1555 psia. The maximum tank design pressure is 1710 psia and the lower limit on the burst disc is 1881 psia. The 1400 psia limit appears to be conservative but flight data on the tank He/He heat exchanger in the absence of a 1-G field is desired to evaluate tank pressure characteristics during the initial burn. LM-1 did not contribute any significant data for such an evaluation.

It should be noted that the standby lifetime is a direct function of the maximum allowable tank pressure which is partially dependent on the engine duty cycle. The longer the low thrust (10 to 20 percent) portion of the first burn, the lower the maximum pressure required at system activation. After activation, there is an increased rate of pressure rise in the SHe tank through the heat transfer by way of the internal He/He heat exchanger. The accompanying low rate of helium usage downstream at low thrust levels compounds the problem. The initial low thrust profile is dictated by the guidance and control system in order to satisfy time response requirements.

## 2. SHe Tank Reproofing/Burst Disc Design

Uprating of the SHe system requires a reproofing of the tanks to a higher pressure level and redesign of the burst disc for a higher rupture pressure. MSC states that it is not possible to reproof the tanks to higher pressure levels since the current proof pressure of 2280 psia (1.33 x Design Limit) approaches the yield limit of the membrane of the lower boss. Uprating requires a proof pressure of 3032 psia. Scheduling considerations would also have been a constraint since SHe tanks have been installed in vehicles through LM-6. It is estimated that six months would be required to redesign and requalify the burst discs with another two months required for retrofit of the tanks.

MSC concludes that the present standby lifetime capability of the SHe system is 131.33 hours. This time cannot presently be increased without redesign or prior to the acquisition of enough flight data to accurately verify the actual tank thermal environment and the performance of the tank internal He/He heat exchanger in the absence of a 1-G field. They do not expect these data to be available before the first lunar mission.

### SHe LUNAR MISSION REQUIREMENTS

The SHe system standby lifetime is presently budgeted between KSC requirements beginning at "topoff" to the start of the lunar launch window and MSC requirements beginning at the start of the launch window to system activation at Descent Orbit Injection (DOI). Total requirements are listed in Table 1 by mission phase. These data indicate a present requirement of 131.0 hours versus the present capability of 131.33 hours.

The insignificant difference between mission requirements and system capabilities emphasizes the fact that flexibility in pad operations and mission planning does not presently exist. Desirable strategies for countdowns and alternate mission planning are severely limited.

KSC pad operations and mission planning time lines are not yet firm but it cannot be assumed that a reduction in the required time will materialize. An increase in time requirements is a distinct possibility.

### FUTURE DEVELOPMENT

The desired flexibility for future mission planning will require a cryogenic SHe tank capable of standby lifetimes

well in excess of the present system capabilities. MSC has under development such a tank which has exhibited a standby lifetime capability in excess of 200 hours. This is a highly flexible tank having no DPS duty cycle constraints. It is comparable in weight to the present tank.

Current plans include the fabrication and design verification testing of a flight weight LM descent sized tank. This effort is programmed to be complete in 24 months. MSC estimates that the new SHe tank could be qualified for flight in 15 months if adequate funding is provided.

#### SUMMARY

Until adequate flight data is available on the LM SHe system thermal environment, the present standby lifetime of 131.33 hours cannot be increased. MSC does not expect to have sufficient data for analysis before the first lunar mission. Assuming favorable results from such an analysis, the standby lifetime may reach the 160 hours discussed in reference 1.

KSC and MSC lunar mission planning is constrained by the limited SHe standby lifetime capability. Margins presently are not adequate for desired flexibility in count-down operations, including hold and recycle, or flight mission time lines. This condition may become critical if it becomes necessary to increase mission requirements or rebudget present capabilities at some future date.

If future mission requirements exceed these capabilities (as hybrid missions would), the helium tank under development at MSC should be aggressively pursued. The present tank cannot be uprated because of structural limitations.

2032-DMD-gmp

*D. M. Duty*  
D. M. Duty

Attachment  
Table 1

#### REFERENCES

1. "A Proposal for Uprating the LM Supercritical Helium (SHe) System" Bellcomm, Inc. Memorandum for File. Case 320, dated March 29, 1968, by D. M. Duty.
2. MSC Memorandum "Request from KSC for Support Data" dated August 5, 1968, by Joseph G. Thibodaus, Jr.

TABLE 1

SHE SYSTEM STANDBY TIME REQUIREMENTS  
(Maximum in Hours)

<u>Mission Phase</u>	<u>MSC Design Timeline</u>	<u>Present Mission Planning</u>	<u>(Free Return Trajectory)</u>
Pre-launch	15.0	20.0	
Launch Window	4.5	6.0 (Built in Hold)	
Earth Orbit (includes ejection and initial const.)	5.58	4.5	
Trans-lunar	100.0	74.0	
Lunar Orbit	6.25	22.0	
TOTAL	131.33	131.0	

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